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REDESCRIPTION OF *PARACOCCUS MARGINATUS* WILLIAMS AND GRANARA DE WILLINK (HEMIPTERA: COCCOIDEA: PSEUDOCOCCIDAE), INCLUDING DESCRIPTIONS OF THE IMMATURE STAGES AND ADULT MALE

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Abstract.—Paracoccus marginatus Williams and Granara de Willink, commonly known as the papaya mealybug was first discovered in the Caribbean in 1994 and was collected in Florida in 1998. To facilitate implementation of control measures we have prepared descriptions, illustrations, and keys for all stages of this species including: First instar, second-instar male and female, third-instar male (prepupa) and female, fourth-instar male (pupa) and female (adult), and fifth-instar male (adult). Comparisons are given between *P. marginatus* and other species of *Paracoccus* as well as other commonly encountered mealybug species in Florida and the Caribbean.

Key Words: mealybugs, Coccoidea, Pseudococcidae, ontogeny, pest, papaya, *Carica papaya,* hibiscus, invasive species, pest, Florida, Caribbean

The genus *Paracoccus* includes some 79 species of varied distribution from the "Austro-Oriental, Ethiopian, Madagasian, Nearctic, Neotropical, New Zealand, Pacific, Palaearctic, and Oriental regions" (Ben-Dov 1994). Although most assigned species have not been recognized as major economic pests, there are two notable exceptions. *Paracoccus burnerae* (Brain) is considered a serious pest of citrus in South Africa (Hattingh 1993) and *Paracoccus marginatus* Williams and Granara de Willink has recently received attention as a pest of papaya and other economically important crops in the Caribbean and Florida.

Paracoccus marginatus or the papaya mealybug was originally reported from the Neotropical Region in Belize, Costa Rica, Guatemala, and Mexico (Williams and Granara de Willink 1992) and is believed to be native to at least part of Mexico and/or Central America (Miller et al. 1999). In 1993 or 1994, it was apparently introduced into the Caribbean Islands where it spread rapidly and is considered a pest of papaya in some areas (Miller et al. 1999). It has subsequently been reported from St. Martin (Matile-Ferrero and Étienne 1996) and Guadeloupe and St-Barthelemy Islands (Matile-Ferrero and Étienne 1998). Other Caribbean distribution records include: Antigua (Watson and Chandler 1999); Bahamas, San Salvador Island and New Providence (Watson, personal communication), Paradise Island (Meyerdirk, personal communication); British Virgin Islands (Watson and Chandler 1999); Cuba (Meyerdirk, personal communication); Dominican Republic (Meyerdirk, personal communication); Haiti (Meyerdirk, personal communication); Montserrat (Watson and Chandler 1999); Nevis (Watson and Chandler 1999);

Table 1. Host plants and references for *Paracoccus marginatus*.

Host plant	Reference
Acacia sp.	Miller et al. (1999)
Acalypha sp.	Miller et al. (1999)
Acalypha wilkesiana Muell.-Arg.	Hamon (personal communication)
Ambrosia cumanensis auct. non Kunth	Williams and Granara de Willink (1992)
Annona squamosa L.	Miller et al. (1999)
Bauhinia sp.	Hamon (personal communication)
Carica papaya L.	Hamon (personal communication)
Carica sp.	Williams and Granara de Willink (1992)
Cestrum nocturnum L.	Hamon (personal communication)
Citrus x paradisi Macfad. (pro sp.)	Hamon (personal communication)
Clerodendrum paniculatum L.	Hamon (personal communication)
Coccoloba sp.	Miller et al. (1999)
Fistulosa sp.	Hamon (personal communication)
Guazuma ulmifolia Lam.	Miller et al. (1999)
Hamelia patens Jacq.	Hamon (personal communication)
Hamelia sp.	Hamon (personal communication)
Hibiscus sp.	Hamon (personal communication)
Hibiscus rosa-sinensis L.	Hamon (personal communication)
Ipomoea carnea Jacq.	Hamon (personal communication)
Ipomoea sp.	Miller et al. (1999)
Jatropha integerrima Jacq.	Hamon (personal communication)
Jatropha sp.	Hamon (personal communication)
Malvaviscus penduliflorus DC.	Hamon (personal communication)
Manihot chlorosticta Standl. & Goldman	Williams and Granara de Willink (1992), Miller et al. (1999)
Manihot esculenta Crantz	Williams and Granara de Willink (1992), Miller et al. (1999)
Mimosa pigra L.	Williams and Granara de Willink (1992)
Parthenium hysterophorus L.	Williams and Granara de Willink (1992), Miller et al. (1999)
Persea americana P. Mill.	Miller et al. (1999)
Plumeria rubra L.	Hamon (personal communication)
Plumeria sp.	Hamon (personal communication)
Rhaphiolepis umbellata (Thunb.) Makino	Hamon (personal communication)
Sida sp.	Williams and Granara de Willink (1992), Miller et al. (1999)
Solanum melongena L.	Miller et al. (1999)
Uniola paniculata L.	Hamon (personal communication)
Zea mays L.	Miller et al. (1999)

Puerto Rico (Meyerdirk, personal communication); St. Barthelemy (Meyerdirk, personal communication); St. Kitts (Watson and Chandler 1999); and U.S. Virgin Islands (Watson and Chandler 1999). Additionally, *P. marginatus* has recently been reported from French Guiana, South America (Matile-Ferrero et al. 2000). *Paracoccus marginatus* was first discovered in the United States in Manatee and Palm Beach counties, Florida in 1998 and has since been collected in Alachua, Brevard, Broward, Collier, Dade, Hillsborough, Manatee, Martin, Monroe, Palm Beach, Pinellas, Polk, Sarasota, and Volusia counties (Hamon, personal communication). Since its introduction into Florida, it has been collected 80 times in 30 different cities on 18 species of hosts. The species has apparently spread rapidly in the state.

Paracoccus marginatus has been reported from more than 25 genera of host plants including economically important crops such as papaya, citrus, yams, cassava, and hibiscus. Papaya mealybug hosts along with associated references are included in Table 1. Although this mealybug has also been recorded from many other hosts, these have yet to be confirmed and are not included in Table 1.

Williams and Granara de Willink (1992) published the first taxonomic paper on *Paracoccus marginatus* and included a description and illustration of the adult female. They also provided descriptions and a key for the 21 species of *Paracoccus* occurring in Central and South America. The purpose of this research is to describe and illustrate all instars (including the adult male and female) of this potentially serious invasive species in order to facilitate its recognition as part of any control initiatives that may be undertaken.

Methods

Terminology in the descriptions follows that of Williams and Granara de Willink (1992) and Gimpel and Miller (1996) for adult females and immatures and that of Afifi (1968) for adult males. Measurements were made with an ocular micrometer using a Leica DMRB compound microscope. Numbers and measurements are from 10 specimens and are given as an average followed by the range in parentheses. Associated enlargements of various structures on the illustrations are not proportional. All specimens studied are from the National Museum of Natural History, Coccoidea Collection, Beltsville, MD. Information listed in the Specimens Examined section is verbatim from information recorded on the microscope slides. The abbreviation "ad." refers to adult specimens.

Tables 3–6 contain 12 of the most common mealybugs in the Caribbean region and were selected for comparison to *P. marginatus*. Included species are: *Dysmicoccus brevipes* (Cockerell); *Ferrisia virgata* (Cockerell); *Maconellicoccus hirsutus* (Green); *Nipaecoccus nipae* (Maskell); *Phenacoccus gossypii* Townsend and Cockerell; *Phenacoccus madeirensis* Green; *Phenacoccus solenopsis* Tinsley; *Planococcus citri* (Risso); *Planococcus minor* (Maskell); *Pseudococcus jackbeardsleyi* Gimpel and Miller; *Pseudococcus longispinus* (Targioni Tozzetti); and *Pseudococcus viburni* (Signoret). *Phenacoccus gossypii* and *P. madeirensis* are listed together as are *Planococcus citri* and *P. minor* because of morphological similarities. There are other species of *Phenacoccus, Pseudococcus,* and *Nipaecoccus* that could be included in this list, but they are also so similar in general appearance to other species in the genus that characters of one species in the genus are sufficient to distinguish all species in the immature instars.

Host plant names included in Table 1 were verified in Integrated Taxonomic Information System (Anonymous 2001).

Results

Paracoccus marginatus Williams and Granara de Willink

Suggested Common Name: Papaya mealybug
(Figs. 1–8)

Key to Instars

1. Without wings or wing buds on thorax . . . 4
– With wings or wing buds on thorax 2
2(1). Genitalia weakly sclerotized, aedeagus absent; wings represented by buds less than ½ length of body, without a vein 3
– Genitalia heavily sclerotized, aedeagus apparent; wings approximately as long as body, with small basal vein (Fig. 8) . . . . . adult male
3(2). Antenna unsegmented; wing buds small, less than length of thorax; head without sclerotization (Fig. 6) . . . . . prepupal male
– Antenna with 10 segments; wing buds large, about same length as thorax; head with weak sclerotization (Fig. 7) . . . . . pupal male
4(1). Antennae 6-segmented 5
Antennae with 7 or 8 segments 8
5(4). Without tubular ducts or with less than 5 such ducts 6
With more than 5 tubular ducts particularly on dorsal abdomen (Fig. 5) . . . . . second-instar male
6(5). Third antennal segment with more than 4 setae; anal-lobe cerarius with at least 1 auxiliary seta 7
– Third antennal segment with 4 setae; anal-lobe cerarius without auxiliary setae (Fig. 4) . . . . . first instar
7(6). Third antennal segment with 5 setae; tibia divided by tarsus 0.9(0.8–1.0) (Fig. 3) . . . . . second-instar female
– Third antennal segment with 9 setae; tibia

divided by tarsus 1 2(1.2–1.4) (Fig. 2) . . . . . third-instar female (in part)

8(4). Antenna 7-segmented; with less than 5 multilocular pores; without vulva (Fig. 2) . . . . . third-instar female (in part)

– Antenna 8-segmented; with more than 5 multilocular pores; with vulva (Fig. 1) . . . . . adult female

Type data.—We have not examined type material of this species, but have studied many of the specimens that were used in the original description but were not included in the type series.

Etymology.—The species epithet is derived from a Latin word meaning enclosed within a border and refers to the border of oral rim tubular ducts (Williams and Granara de Willink 1992).

Adult Female
(Fig. 1)

Field features.—Body yellow, dusted with mealy wax not thick enough to hide body color, without discrete bare areas on dorsum, with many short waxy filaments around body margin. Ovisac developed beneath and behind adult female.

Slide-mounted characters.—Body 2.2(1.5–2.7) mm long, 1.4(0.9–1.7) mm wide.

Dorsum with 16(14–17) pairs of cerarii; cerarii 1, 2, 4, 5, 7, and 9 with 2 conical setae (Fig. 1M); cerarii 3, 6, and 16 with 3(2–3) conical setae; cerarii 8, 11, and 17 with 2(0–2); cerarii 10 and 14 with 1(0–2) conical setae; cerarii 12, 13, and 15 with 2(0–3) conical setae. Cerarius 12 without auxiliary setae, with 2(0–3) conical setae, 5(0–8) trilocular pores, 1(0–3) discoidal pores. Anal-lobe cerarius (Fig. 1I) with 1(1–3) auxiliary setae (Fig. 1J), 2 conical setae, 13(10–18) trilocular pores (Fig. 1C), 2(0–3) discoidal pores (Fig. 1K). Dorsal body setae (Fig. 1L) more slender than cerarian setae. Multilocular pores absent; trilocular pores scattered over surface, most abundant near setae; discoidal pores rare, about ½ diameter of trilocular pore. Oral-rim tubular ducts (Fig. 1B) usually restricted to marginal areas associated with cerarii, 1 specimen examined with 1 mediolateral duct on segment I and 1 in medial area of mesothorax; of 21 specimens examined cerarius 1 without associated oral rim, cerarius 2 with associated oral rim in 20 of 21 specimens, cerarius 3 with 4 on 21 specimens, cerarius 4 with 12 on 21, cerarius 5 with 11 on 21, cerarius 6 with 17 on 21, cerarius 7 with 18 on 21, cerarius 8 with 20 on 21, cerarii 9 and 10 without associated oral rims, cerarius 11 with 15 on 21, cerarius 12 with 4 on 21, cerarii 13, 15, and 16 without associated oral rim, cerarius 14 with 2 on 21, and cerarius 17 with 15 oral rims on 21 specimens. Oral-collar tubular ducts absent. Longest submedial seta on segment VII 10(8–14) μ long; 1(0–2) submedial setae on segment VIII, when present longest seta 13(8–18) μ long.

Anal-ring seta 136(120–150) μ long; 1.4(1.2–1.7) times as long as width of anal ring.

Venter with multilocular pores (Fig. 1G) usually in posterior and anterior bands on segments VI–VIII and restricted to posterior band on segments IV and V, 1 or 2 specimens with 1 or 2 pores on segment III or with a few pores on anterior margins of segments IV and V; 3 of 10 specimens with 1 multilocular pore near base of front or hind leg. Trilocular pores concentrated near setal bases. Discoidal pores uncommon, of same size as on dorsum. Oral-rim tubular ducts in mediolateral areas from prothorax to segment I, with 4(3–6) ducts on each side of body. Oral-collar tubular ducts of 1 size, in conspicuous marginal clusters along body margin from segments II–VII, often with 2 or 3 pores on segment I, also present in medial and mediolateral areas of abdominal segments III–VIII, present on thorax in seta clusters near hind 2 pairs of legs, occasionally with 1 or 2 along body margin of thorax especially in area laterad of anterior spiracle and front legs, absent from head. Setae as follows: 4 cisanal (Fig. 1H), longest 52(45–68) μ long; longest anal-lobe seta 170(155–200) μ long; longest seta on trochanter 104(95–110) μ long. Anal-lobe

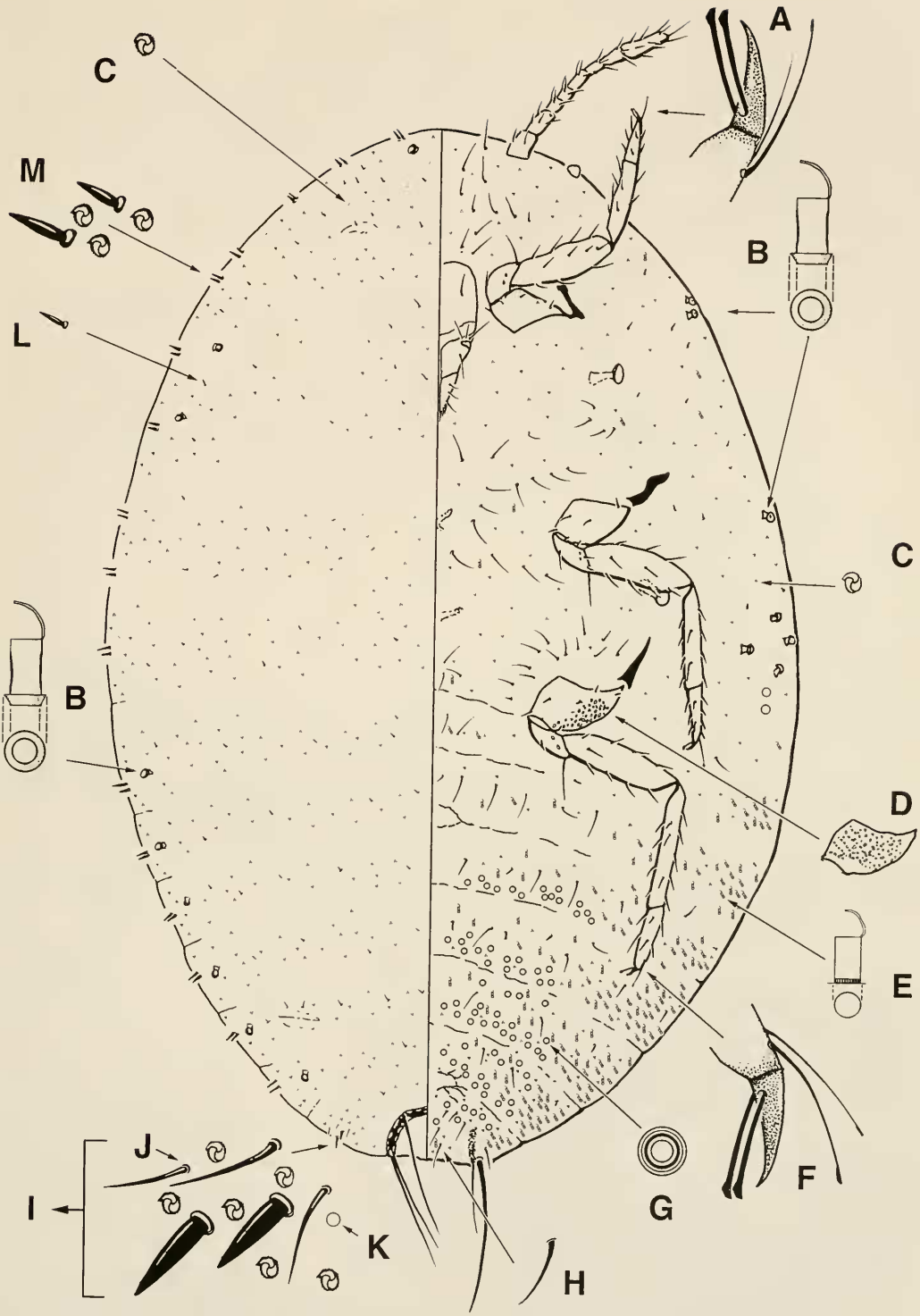

Fig. 1. Adult female of *Paracoccus marginatus*. A, Detail of front leg. B, Oral-rim tubular duct. C, Trilocular pore. D, Translucent pores. E, Oral-collar tubular duct. F, Detail of hind leg. G, Multilocular pore. H, Cisanal seta. I, Anal-lobe cerarius. J, Auxiliary seta. K, Discoidal pore. L, Dorsal body seta. M, Cerarian seta.

bar conspicuously wider than base of anal bar seta.

Circulus 63(40–80) μ wide, generally divided by intersegmental line. Labium 137(125–162) μ long. Antenna 8-segmented, 372(335–400) μ long. Legs with translucent pores restricted to hind coxa, ventral surface (when leg is lying flat as shown in illustration) with 40(14–62) pores, dorsal surface (Fig. 1D) with 79(54–108) pores. Hind femur 209(195–225) μ long; hind tibia 211(185–228) μ long; hind tarsus 94(91–100) μ long. Hind tibia/tarsus 2.2(2.0–2.3); hind femur/tarsus 1.0(0.9–1.1). Length of hind femur divided by greatest width of hind femur 3.7(3.0–4.2). Hind tibia with 15(14–19) setae. Claw digitules on all legs clubbed, approximately same size. Tarsal digitules (Fig. 1F) on hind 2 pairs of legs clubbed, each tarsus with 1 digitule noticeably longer and with club slightly larger than other; tarsal digitules (Fig. 1A) on front pair of legs of 2 different sizes and shapes, 1 digitule on each tarsus clubbed and robust, other digitule without club, slender.

Notes.—The above description is based on 240 specimens from 41 localities. The adult female can be distinguished from all other instars by having multilocular pores, translucent pores on hind coxa, and a vulva.

Third-instar Female
(Fig. 2)

Slide-mounted characters.—Body 1.1(0.7–1.8) mm long, 0.7(0.3–1.1) mm wide.

Dorsum with 6(1–10) pairs of cerarii; cerarii indefinite, when present, with 2 conical setae and 1 trilocular pore between conical setae. Cerarius 12 absent. Anal-lobe cerarius with 1(1–2) auxiliary setae, 2 conical setae, 5(4–7) trilocular pores, 0(0–1) discoidal pores. Dorsal body setae more slender than cerarian setae. Multilocular pores absent; trilocular pores scattered over surface, most abundant near setae; discoidal pores rare, about ½ diameter of trilocular pore. Oral-rim tubular duct rarely present near position of cerarius 8 (of 10 specimens examined, 4 had 1 oral rim or large oral collar on at least one side of body). Oral-collar tubular ducts absent. Longest submedial seta on segment VII 7(5–10) μ long; 1(0–2) submedial setae on segment VIII, when present longest seta 7(5–9) μ long.

Anal-ring seta 87(78–92) μ long; 1.6(1.3–1.8) times as long as width of anal ring.

Venter with multilocular pores absent (present on 1 of 10 specimens examined, restricted to segment VIII). Trilocular pores concentrated near setal bases. Discoidal pores uncommon, of same size as on dorsum. Oral-rim tubular ducts sometimes present near body margin on abdominal segment II, III, or on metathorax (of 10 specimens examined, 4 had 1 or 2 oral rims or large oral collar on at least one side of body). Oral-collar tubular ducts absent. Setae as follows: 4 cisanal, longest 33(22–50) μ long; longest anal-lobe seta 132(112–158) μ long; longest seta on trochanter 63(50–85) μ long. Anal-lobe bar slightly narrower than on adult female.

Circulus 47(22–80) μ wide, generally divided by intersegmental line. Labium 85(70–100) μ long. Antenna 6- or 7-segmented (of 10 specimens examined 5 had 6-segments with weak indication of partial division between segments 3 and 4), when 6-segmented, segment 3 with 9 setae, 233(205–262) μ long. Legs without translucent pores. Hind femur 114(100–138) μ long; tibia 108(98–127) μ long; tarsus 84(80–90) μ long. Hind tibia/tarsus 1.2(1.2–1.4); hind femur/tarsus 1.1(1.0–1.2). Length of hind femur divided by greatest width of hind femur 2.5(2.0–3.1). Hind tibia with 9(7–10) setae. Claw and tarsal digitules same as on adult female except sometimes 1 claw digitule slightly smaller that other.

Notes.—The above description is based on 42 specimens from 12 localities. The third-instar female can be distinguished from all other instars by having 6- or 7-segmented antennae, when 6-segmented with

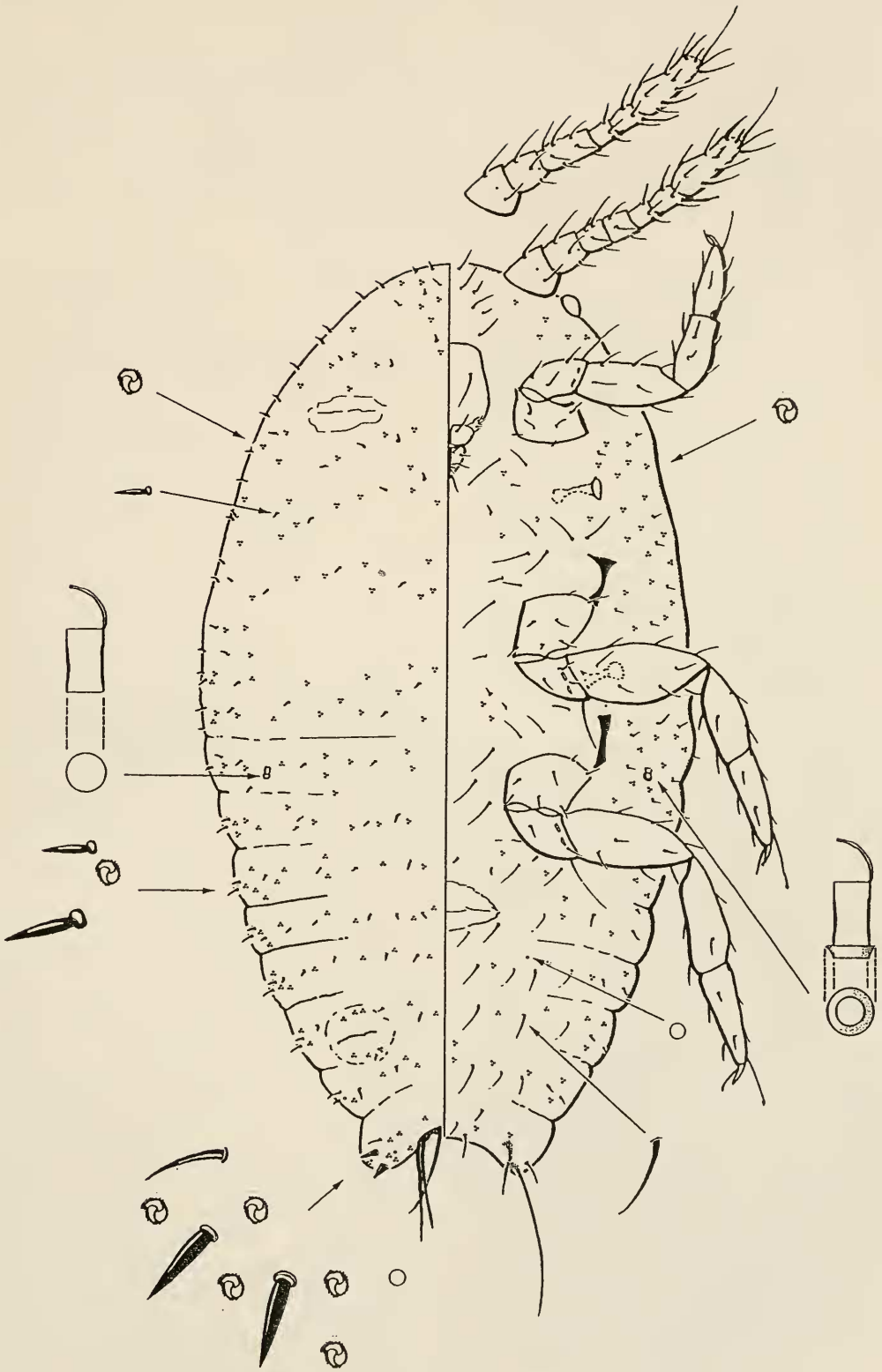

Fig. 2. Third-instar female of *Paracoccus marginatus*.

hind tibia divided by hind tarsus length usually 1.2, and about 9 setae on the hind tibia.

Second-instar Female (Fig. 3)

Field features.—Body color yellow.

Slide-mounted characters.—Body 0.7(0.5–0.8) mm long, 0.4(0.3–0.5) mm wide.

Dorsum with 6(4–11) pairs of cerarii; cerarii indefinite, when present, with 2 conical setae and 1 trilocular pore between conical setae. Cerarius 12 absent. Anal-lobe cerarius with 1 auxiliary setae, 2 conical setae, 2(2–3) trilocular pores, sometimes with 1 discoidal pore. Dorsal body setae more slender than cerarian setae. Multilocular pores absent; trilocular pores scattered over surface, most abundant near setae; discoidal pores rare, about ½ diameter of trilocular pore. Oral-rim tubular ducts absent. Oral-collar tubular ducts absent. Longest submedial seta on segment VII 6(5–6) μ long; without submedial setae on segment VIII.

Anal-ring seta 60(52–70) μ long; 1.5(1.3–1.8) times as long as width of anal ring.

Venter with multilocular pores absent. Trilocular pores concentrated near setal bases, absent in medial area of abdomen. Discoidal pores rare. Oral-rim tubular ducts absent. Oral-collar tubular ducts absent. Setae as follows: 4 cisanal, longest 20(18–25) μ long; longest anal-lobe seta 95(88–102) μ long; longest seta on trochanter 49(42–55) μ long. Anal-lobe bar narrower than on adult female.

Circulus 40(20–75) μ wide, generally divided by intersegmental line. Labium 69(62–75) μ long. Antenna 6-segmented, 173(152–185) μ long; antennal segment 3 with 5 setae. Legs without translucent pores. Hind femur 78(72–82) μ long; hind tibia 66(58–72) μ long; hind tarsus 69(65–72) μ long. Hind tibia/tarsus 0.9(0.8–1.0); hind femur/tarsus 1.2(1.1–1.3). Length of hind femur divided by greatest width of hind femur 2.3(2.1–2.5). Hind tibia with 9(8–9) setae. Claw and tarsal digitules same as on adult female except 1 claw digitule conspicuously smaller on all legs.

Notes.—The above description is based on 64 specimens from 9 localities. The second-instar female can be distinguished from all other instars by lacking oral-collar tubular ducts and multilocular pores, and by having 5 setae on the third antennal segment.

First Instar (Gender Not Determined) (Fig. 4)

Slide-mounted characters.—Body 0.4(0.3–0.5) mm long, 0.2(0.2–0.3) mm wide.

Dorsum with 9(7–10) pairs of cerarii; cerarii indefinite, when present, with 2 conical setae and 1 trilocular pore between conical setae. Cerarius 12 absent. Anal-lobe cerarius without auxiliary setae, 2 conical setae, 1 trilocular pore, without discoidal pores. Dorsal body setae more slender than cerarian setae. Multilocular pores absent; trilocular pores scattered over surface, forming 2 longitudinal lines on each side of abdomen, excluding cerariian setae. Discoidal pores absent. Oral-rim tubular ducts absent. Oral-collar tubular ducts absent. Longest submedial seta on segment VII 5(4–8) μ long; without submedial setae on segment VIII.

Anal-ring seta 37(30–42) μ long; 1.4(1.2–1.6) times as long as width of anal ring.

Venter without multilocular pores. Trilocular pores restricted to 10 positions on each side of body on head, thorax, and anterior abdomen (see Fig. 4 for position labels); triloculars in positions 1 to 7 and 10 rarely absent, pores in positions 8 and 9 often absent. Discoidal pores in submarginal line on each side of abdomen, usually with 1 pore posterior of each spiracle. Oral-rim and oral-collar tubular ducts absent. Setae as follows: 4 cisanal, longest 17(12–22) μ long; longest anal-lobe seta 58(45–69) μ long; longest seta on trochanter 38(35–42) μ long. Anal-lobe bar narrower than on adult female.

Circulus 37(20–55) μ wide, generally di-

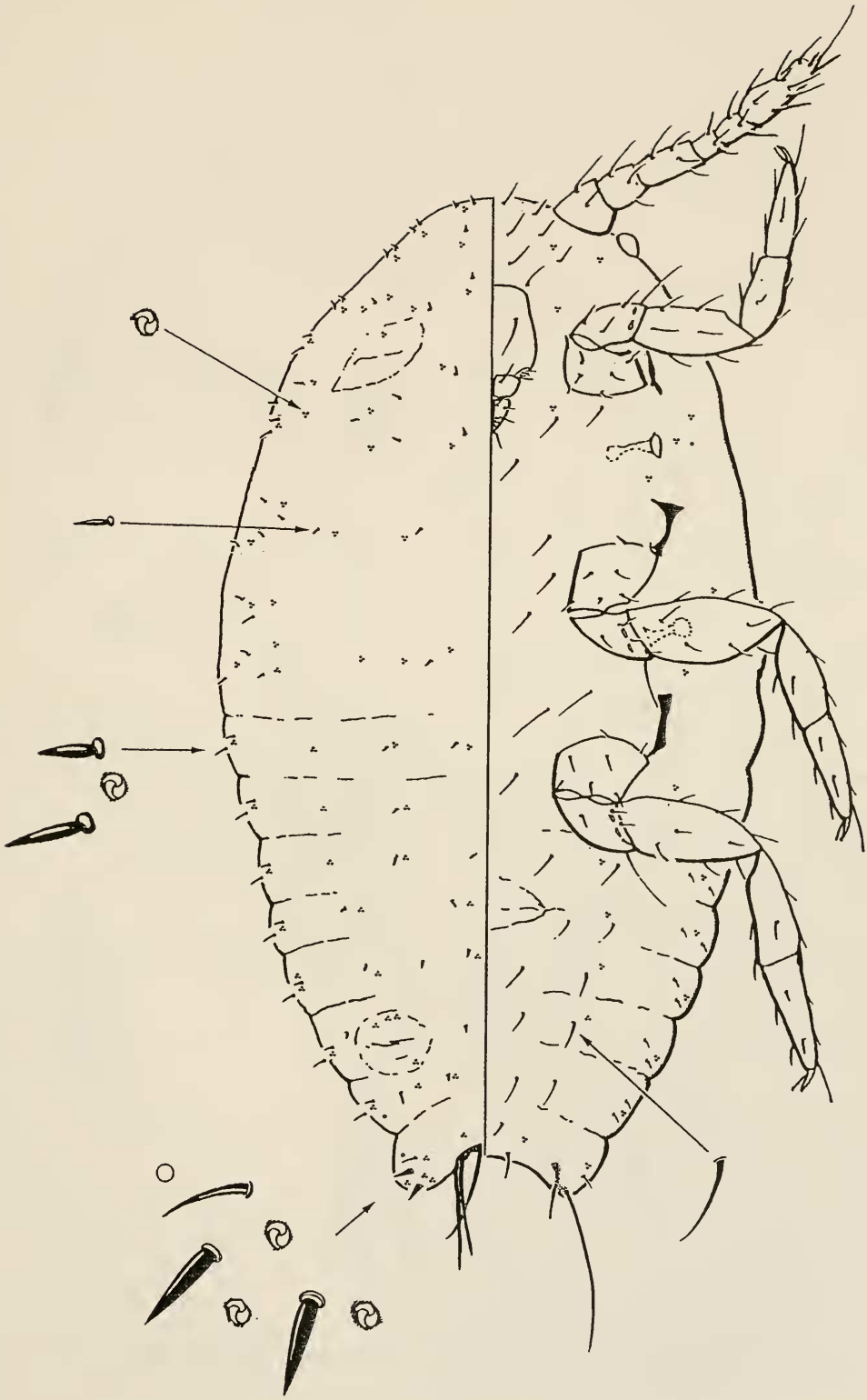

Fig. 3. Second-instar female of *Paracoccus marginatus*.

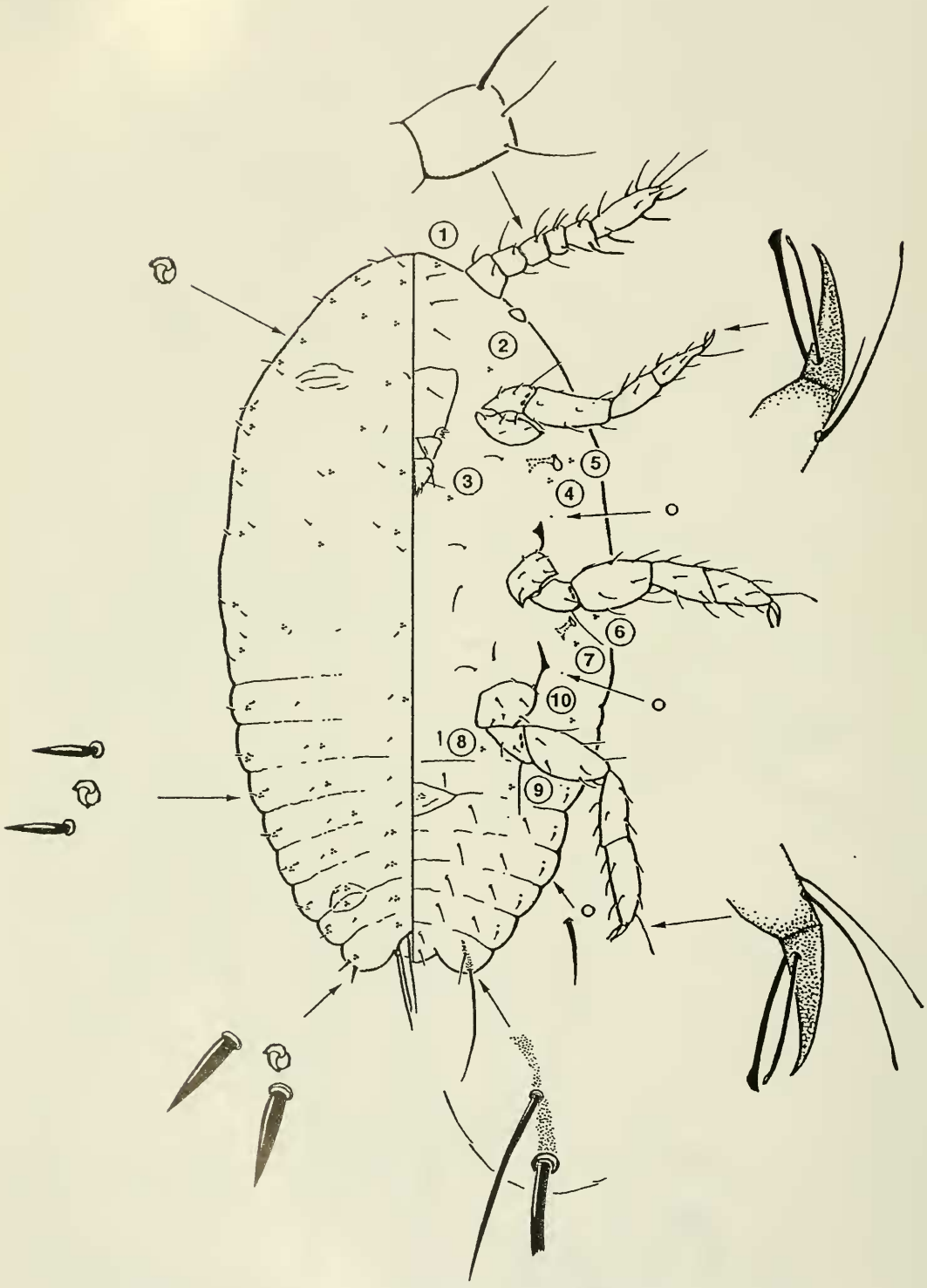

Fig. 4. First-instar of *Paracoccus marginatus*, gender not determined. Numbers refer to positions of ventral trilocular pores.

vided by intersegmental line. Labium 48(44–52) μ long. Antenna 6-segmented, 132(120–148) μ long; antennal segment 3 with 4 setae. Legs without translucent pores. Hind femur 59(55–62) μ long; hind tibia 50(45–55) μ long; hind tarsus 57(53–62) μ long. Hind tibia/tarsus 0.9(0.8–0.9); hind femur/tarsus 1.2(1.1–1.3). Length of hind femur divided by greatest width of hind femur 2.3(1.8–2.5). Hind tibia with 9 setae. Claw and tarsal digitules same as on adult female except 1 claw digitule conspicuously smaller on all legs.

Notes.—The above description is based on 86 specimens from 6 localities. The first-instar can be distinguished from all other instars by having no auxiliary setae in the anal-lobe cerarius, 2 longitudinal lines of trilocular pores on dorsal abdomen on each side of body (excluding cerariian setae), and antennal segment 3 with 4 setae.

Second-instar Male
(Fig. 5)

Field features.—Body color usually pink, occasionally yellow.

Slide-mounted characters.—Body 0.6(0.5–1.0) mm long, 0.3(0.2–0.6) mm wide.

Dorsum with 4(2–5) pairs of cerarii; cerarii indefinite, when present, with 2 conical setae and 1 trilocular pore between conical setae. Cerarius 12 absent. Anal-lobe cerarius with 1(1–2) auxiliary setae, 2 conical setae, 2(2–3) trilocular pores, without discoidal pores. Dorsal body setae more slender than cerarian setae. With 1(0–2) multilocular pores in medial areas of thorax and/or head, present on 6 of 10 specimens examined; trilocular pores scattered over surface, most abundant near setae; discoidal pores rare, about ½ diameter of trilocular pore. Oral-rim tubular ducts absent. Oral-collar tubular ducts abundant over surface, of 1 size. Longest submedial seta on segment VII 6(5–8) μ long; without submedial setae on segment VIII.

Anal-ring seta 54(48–58) μ long; 1.3(1.2–1.5) times as long as width of anal ring.

Venter with multilocular pores mesad of each pair of legs, for hind pair of legs located on segment III, with 4(2–5) pores on body. Trilocular pores concentrated near setal bases. Discoidal pores rare. Oral-rim tubular ducts absent. Oral-collar tubular ducts of 2 sizes: larger size same as on dorsum, located marginally; smaller size present in longitudinal line along submargin of abdomen. Setae as follows: 4 cisanal, longest 21(17–26) μ long; longest anal-lobe seta 91(83–108) μ long; longest seta on trochanter 47(40–55) μ long. Anal-lobe bar narrower than on adult female.

Circulus 50(40–75) μ wide, generally divided by intersegmental line. Labium 67(62–72) μ long. Antenna 6-segmented, 171(160–188) μ long; antennal segment 3 with 5 setae. Legs without translucent pores. Hind femur 82(75–92) μ long; hind tibia 68(61–80) μ long; hind tarsus 62(52–70) μ long. Hind tibia/tarsus 1.1(1.0–1.2); hind femur/tarsus 1.2(1.1–1.4). Length of hind femur divided by greatest width of hind femur 2.6(2.2–3.0). Hind tibia with 9(8–9) setae. Claw and tarsal digitules same as on adult female except 1 claw digitule conspicuously smaller on all legs.

Notes.—The above description is based on 86 specimens from 7 localities. The second-instar male can be distinguished from all other instars by having dorsal oral-collar tubular ducts and multilocular pores near 1 or more pairs of legs. In addition, live and alcohol preserved specimens tend to appear more narrowly elongate than other associated second-instar females, third-instar females, or first instars.

Both field collected and laboratory reared early instars of *P. marginatus* exhibit pink and yellow forms. We hypothesize that the pink forms are males. Pink forms were collected in the field on St. Kitts, W.I. In addition, Richard Warkentin (USDA, APHIS-PPQ, Biological Control Technical Specialist) collected and sorted a vial of pink specimens and a vial of yellow ones from the Papaya mealybug rearing facilities in St. Thomas, U.S.V.I. However, the results from

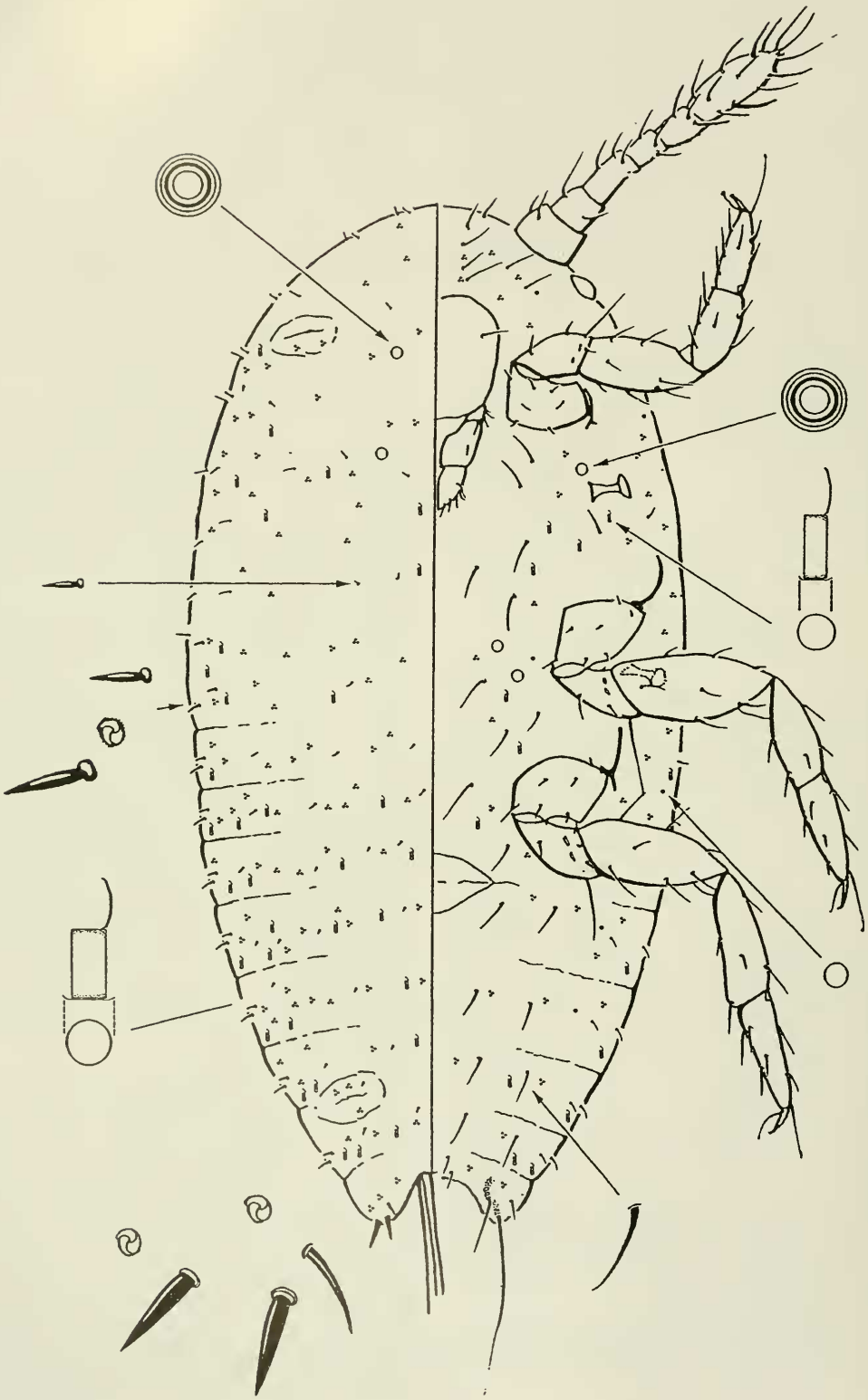

Fig. 5. Second-instar male of *Paracoccus marginatus*.

both collection sites were inconclusive. Although field collected pink forms were mostly second instar males, there were a few second instar females present. Results of the laboratory reared specimens were also inconclusive. While specimens of the pink form yielded only second instar males, specimens of the yellow form yielded both second instar males and second instar females although there were many more females than males. Contamination, especially for field collected specimens may be a possibility for the discrepancies but, this is probably unlikely for the specimens collected at the rearing facilities.

Third-instar Male (Prepupa) (Fig. 6)

Slide-mounted characters.—Body 0.9(0.8–1.1) mm long, 0.4(0.3–0.4) mm wide.

Dorsum without cerarii; posterolateral margins of segments V, or VI, VII, and VIII each with 2 setae conspicuously longer than remaining setae on abdominal segments. Multilocular pores in medial areas of head, forming row on prothorax and metathorax, usually without pores on mesothorax, occasionally with 1 or 2 medially, in rows on most abdominal segments, fewer in medial area, absent from segments VIII and IX; trilocular pores absent; discoidal pores rare. Oral-rim tubular ducts absent. Oral-collar tubular ducts present around body margin, medial and submedial ducts sometimes present on prothorax, metathorax and 1 or 2 abdominal segments. Longest submedial seta on segment VII 18(15–20) μ long; without submedial setae on segment VIII.

Anal-ring setae absent; anal ring 25(20–28) μ wide.

Venter with multilocular pores near anterior margin on head, near spiracles, legs, and in medial areas of pro- and mesothorax on thorax, in rows on abdominal segments, sparse medially, absent from segments VIII and IX. Trilocular pores absent. Discoidal pore located near each pair of legs. Oral-rim tubular ducts absent. Oral-collar tubular ducts restricted to margin. Longest anal-lobe seta 67(50–78) μ long.

Circulus appearing collapsed, 62(45–98) μ wide, resting on intersegmental line. Labium absent. Antennal segments indistinct, 226(215–248) μ long. Hind femur 90(82–95) μ long; division between hind tibia and tarsus indistinct, hind tibia + tarsus 134(130–140) μ long. Length of hind femur divided by greatest width of hind femur 2.7(2.2–3.0). Wing buds of mesothorax protruding from lateral margin, 67(50–78) μ long. Hamulohalterae represented by small swelling on lateral margin of metathorax.

Notes.—The above description is based on 16 specimens from 3 localities. The prepupa can be distinguished from all other instars by having multilocular pores, oral-collar tubular ducts, antennae without definite segmentation, tibia + tarsus fused, no labium, no aedeagus, and no definite constriction for the head.

Fourth-instar Male (Pupa) (Fig. 7)

Slide-mounted characters.—Body 1.0(0.9–1.0) mm long, 0.3(0.3–0.4) mm wide.

Dorsum without cerarii; posterolateral margins of segments III, IV, or V, to segment VIII each with 2 setae conspicuously longer than remaining setae on abdominal segments. Multilocular pores absent from head, forming conspicuous row on prothorax, mediolateral cluster on metathorax, without pores on mesothorax, in mediolateral clusters on each side of abdominal segments I–VI or VII; trilocular pores absent; discoidal pores associated with multilocular and oral collars. Oral-rim tubular ducts absent. Oral-collar tubular ducts present near body margin of prothorax and abdominal segments I or II to VII or VII, forming clusters of 2(1–5) ducts. Longest submedial seta on segment VII 20(16–28) μ long; without submedial setae on segment VIII.

Anal-ring setae absent; anal ring 27(25–30) μ wide.

Venter with multilocular pores absent

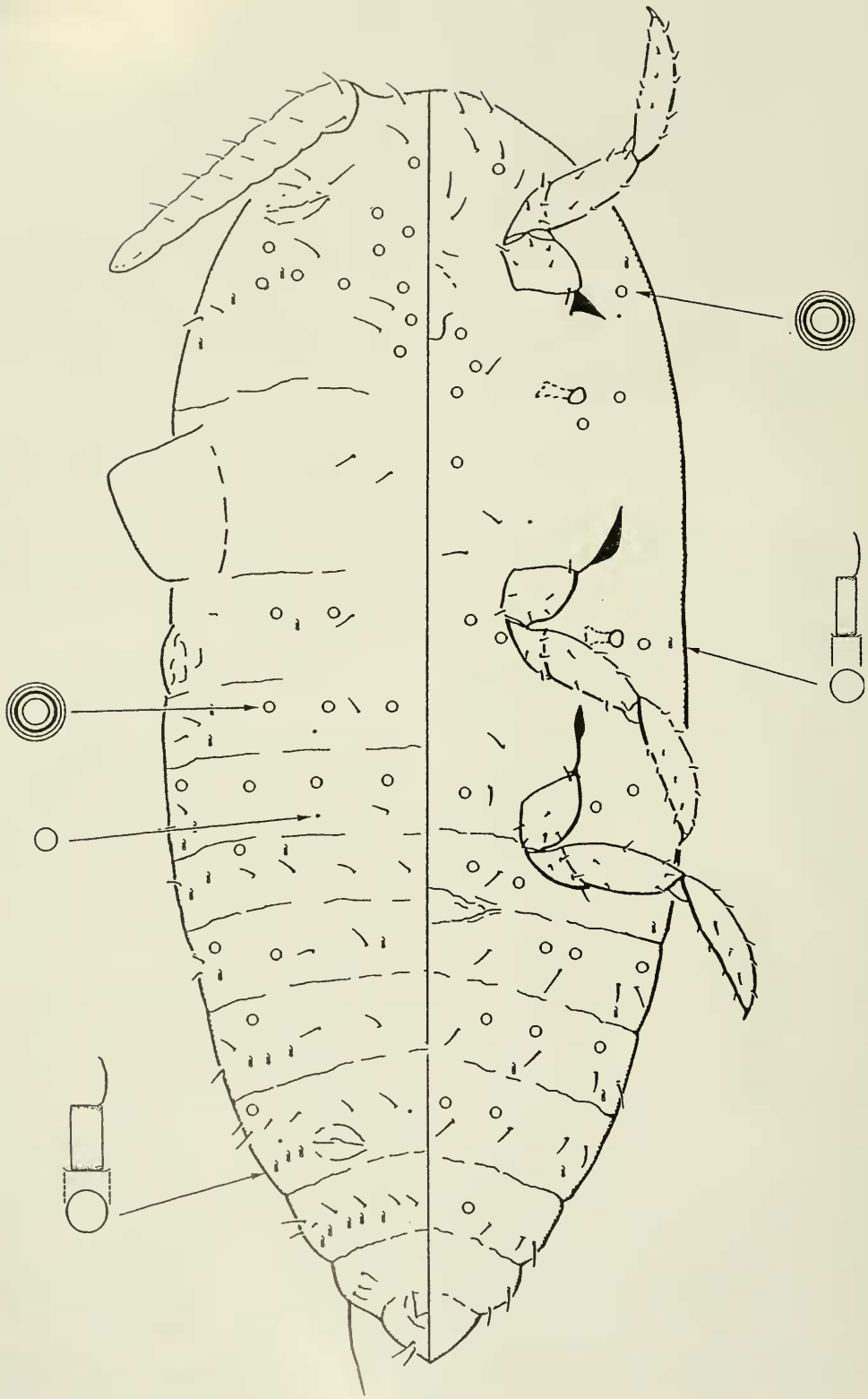

Fig. 6. Third-instar male or prepupa of *Paracoccus marginatus*.

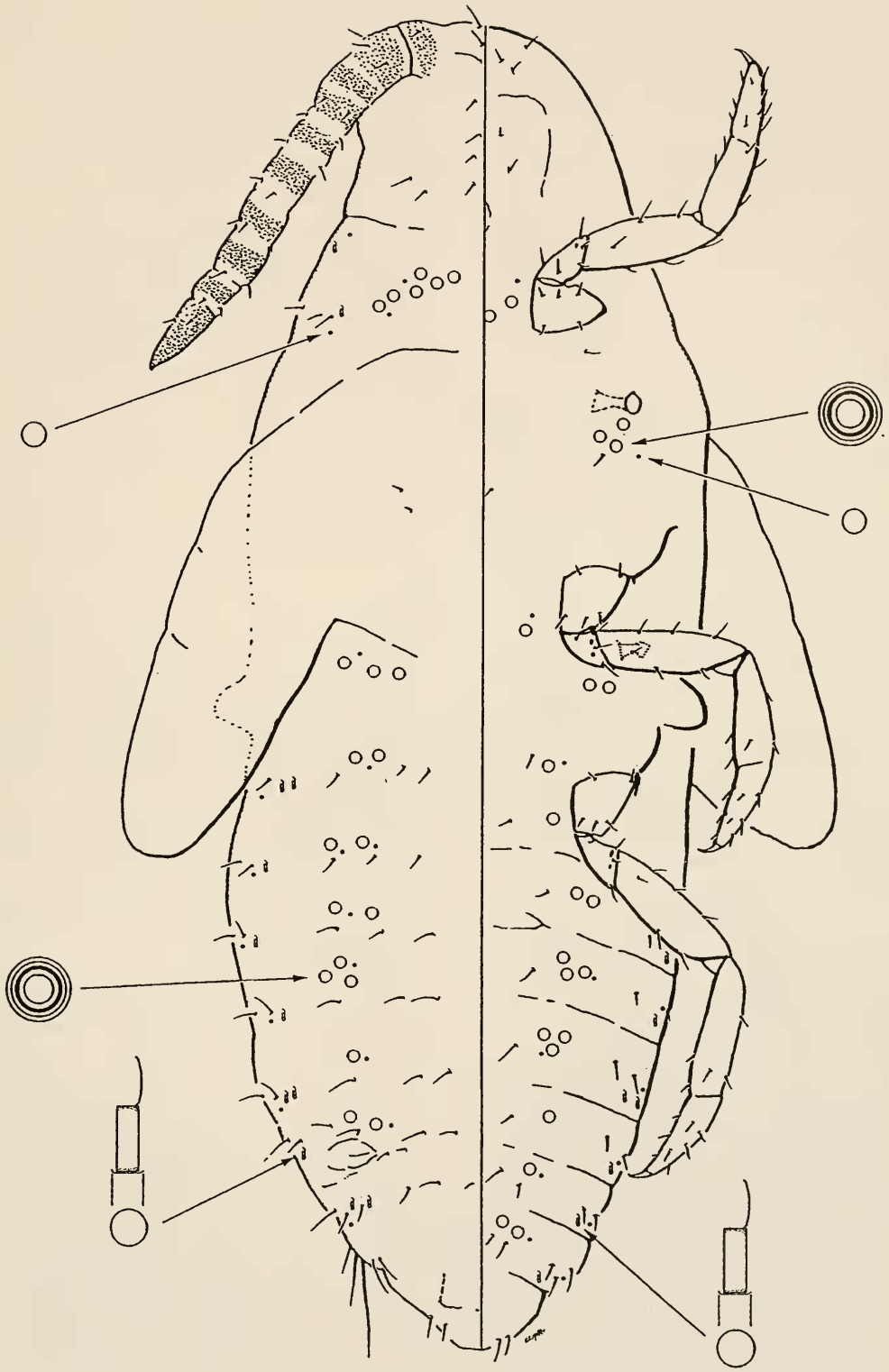

Fig. 7. Fourth-instar male or pupa of *Paracoccus marginatus*.

from head, row of pores between front coxae, present on remainder of thorax near spiracles and legs, in mediolateral clusters of 2(1–4) pores on each side of segments II–VI, VII, or VIII. Trilocular pores absent. Discoidal pores associated with oral-collars and multiloculars. Oral-rim tubular ducts absent. Oral-collar tubular ducts present near body margin of prothorax usually forming cluster of several ducts, sometimes absent from abdomen or with 1 duct near body margin on each of abdominal segments II–VII or VIII. Longest anal-lobe seta 60(48–72) μ long.

Circulus ill-defined. Labium absent. Antenna 10-segmented, 357(345–375) μ long. Hind femur 109(105–115) μ long; hind tibia 111(105–112) μ long; hind tarsus 80(75–88) μ long. Hind tibia/tarsus 1.4(1.3–1.5); hind femur/tarsus 1.0. Length of hind femur divided by greatest width of hind femur 3.3(3.2–3.4). Wing buds of mesothorax protruding from lateral margin, 336(250–385) μ long. Hamulohalterae 36(22–42) μ long.

Notes.—The above description is based on 8 specimens from 1 locality. The pupa can be distinguished from all other instars by having multilocular pores, oral-collar tubular ducts, 10 segmented antennae, no labium, no aedeagus, and a slight constriction between the thorax and head.

Adult Male
(Fig. 8)

Slide-mounted characters.—Body elongate oval, 1.0(0.9–1.1) mm long; greatest width at thorax 0.3(0.2–0.3) mm.

Dorsum with 1 pair of tail-forming pore clusters; each cluster with 2 elongate setae approximately 250 μ long, 1 sometimes 2 additional shorter setae, 38(34–42) multilocular pores, and 1 or 2 discoidal pores. Multilocular pores in marginal areas of prothorax and each abdominal segment, with 5(3–7) on each side of segment I, 2(1–3) on each side of segment II, 2(1–2) on III, 2(1–3) on IV, 2(1–3) on V, 2(1–3) on VI, 1(1–2) on each side of segment VII, multilocular pores with 4 or 5 loculi, quinquelocculars predominate (Fig. 8G); normally without pores on head (1 of 10 specimens with 1 pore near lateral arm of midcranial ridge). Discoidal pores (Fig. 8F) associated with lateral abdominal multilocular pores. Body setae bristle shaped. Small abdominal tergites present on mid-dorsum of segments I–III and dorsum of segment VIII. Dorsal abdominal tergites usually without associated setae. Metapostnotal ridge conspicuous. Scutellum rectangular, with several medial setae. Scutum sclerotized throughout except for a median longitudinal clear area which bears several setae. Prescutum rectangular with well defined prescutal ridge, weakly defined prescutal suture and several setae. Pronotal ridge heavily sclerotized. Hamulohalterae 75(67–82) μ long, with 1 apical hooked seta. Mesothoracic wings 932(889–988) μ long, each with 2–3 basal setae. Head width 180(148–193) μ; dorsal eye 34(30–40) μ in diameter, lateral ocellus 17(12–20) μ in diameter and located at junction of preocular and postocular ridges. Dorsal arm of midcranial ridge (Fig. 8A) extending beyond posterior margin of dorsal eye. Median crest weakly sclerotized with several setae. Ocular sclerite weakly sclerotized.

Penial sheath (Fig. 8C and 8E) 95(86–106) μ long, 70(62–74) μ wide with distinct ventral lobes; length/width ratio 1.4. Aedeagus (Fig. 8D) 68(54–79) μ long, broad and apically truncate.

Venter with hair-like setae only, present medially, submedially and laterally of most abdominal segments as well as few scattered prosternal and basisternal setae. Abdominal sclerotization confined to segment VIII. Prosternal ridge well developed, sternite weakly sclerotized. Preoral ridge weakly developed. Ocular sclerite weakly sclerotized near ventral eye. Ventral midcranial ridge well developed, with lateral arms. Ventral eye 39(32–44) μ in diameter.

Antenna 10-segmented with bristle-shaped and fleshy setae, capitate setae present on apical segment; segments I 37(30–40) μ long (Fig. 8H); II 55(49–62) μ long

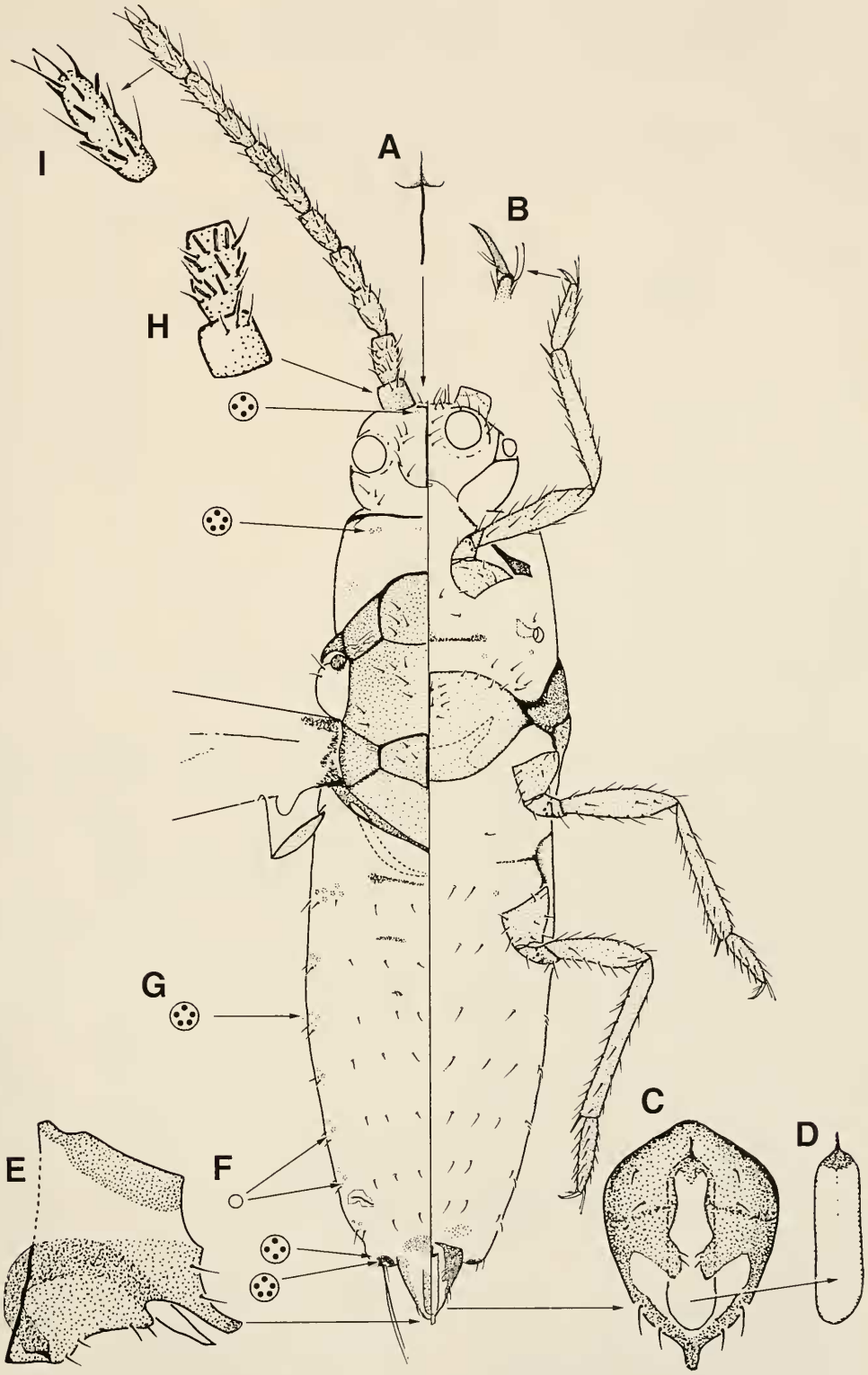

Fig. 8. Adult male of *Paracoccus marginatus*. A, Frontal view of midcranial ridge. B, Detail of front leg. C, Ventral view of penial sheath. D, Aedeagus. E, Lateral view of penial sheath. F, Discoidal pore. G, Quinquelocular pore. H, Detail of scape and pedicel. I, Detail of apical segment.

Table 2. Morphological comparisons of New World *Paracoccus*. Bold indicates characters that differ from *Paracoccus marginatus*.

Paracoccus Species	Circulus	Number of Cerarii	Oral Rim Distribution	Marginal Cluster Oral Collars Near Anterior Spiracle	Pores on Hind Tibiae
marginatus	yes	16–17	margin only	no	no
alazanensis	yes	17	**margin and abdomen**	no	**yes**
ascius	yes	17	**scattered**	**yes**	**yes**
baccharidicola	yes	**7**	**scattered**	**yes**	**yes**
circuliprivis	**no**	**7**	**margin and thorax**	no	**yes**
decorus	**no**	**7–9**	**throughout except head**	no	**yes**
ferrisi	**variable**	12–17	**usually margin and abdomen**	**yes**	**yes**
hamoni	yes	**12**	**scattered**	no	**yes**
herreni	yes	16	**scattered**	**yes**	**yes**
juniperi	yes	5–17	**scattered**	**yes**	**yes**
lycopersici	yes	**4–7**	**scattered**	**yes**	**yes**
mexicanus	yes	15–17	**scattered**	no	**yes**
myrtacearum	**no**	**14**	**scattered**	no	**yes**
oneratus	yes	**5**	**many, scattered**	no	**yes**
ordinis	yes	15–16	**scattered**	**yes**	**yes**
reductus	yes	**0**	**absent**	no	**yes**
salviacola	yes	16	**scattered**	**yes**	**yes**
solani	**variable**	**6–7**	**scattered**	no	**yes**
townsendi	yes	**13**	**absent**	**yes**	no
turrialbensis	**no**	**7**	**abdomen**	no	**yes**
villanuevai	**yes**	17	**scattered**	**yes**	no

(Fig. 8H); III 68(62–74) μ long; VI 52(45–57) μ long; VII 53(47–59) μ long; VIII 53(47–59) μ long; IX 46(37–49) μ long; X 46(49–69) μ long (Fig. 8I); total length 534(469–563) μ long. Hind femur 145(133–148) μ long; hind tibia 199(163–222) μ long; hind tarsus 83 (69–86) μ long; hind tarsal claw 27(22–32) μ long; hind femur/tibia ratio 0.7; hind tibia/tarsus ratio 2.4(2.3–2.5); leg setae bristle shaped. Tarsal digitules capitate; claw digitules acute (Fig. 8B).

Notes.—The above description is based on 64 specimens from 8 localities. The adult male can be distinguished from all other instars by having a distinct aedeagus, lateral pore clusters, a heavily sclerotized thorax and head, and by having well-developed wings.

Specimens Examined

UNITED STATES: Florida: Broward County, Ft. Lauderdale, on *Hibiscus* sp., 5-XI-1998, by W. Thiel. Manatee County, Bradenton, on *H. rosa-sinensis,* 24-VII-1998, by W. Clifton (2 ad. ♀). Palm Beach County, Boca Raton, on *Hibiscus rosa-sinensis,* 1998, by J. Lofquist (1 ad. ♀). BRITISH VIRGIN ISLANDS: Great Camanoe Island, on *Ipomoea* sp., 16-X-1996, by R. F. Denno (7 ad. ♀). DOMINICAN REPUBLIC: Locality unknown, on *Persea americana,* 19-VII-1994, by J. Sanchez (1 ad. ♀). MEXICO: Baja California—La Paz, on *Carica papaya,* 13-IX-1978, by G. Buxton (16 ad. ♀, 3 third-instar ♀, 3 second-instar ♂). Colima—Cofradia de Juarez, on *Carica papaya,* 8-VI-1999, by H. González, J. Villaneuva, D. R. Miller (1 ad. ♀); Crucero de Perquillos, on *Carica papaya* and *Manihot esculenta,* 8-VI-1999, by H. González, J. Villaneuva, D. R. Miller (3 ad. ♀); Rinxon de Lopez near Ameria, on *Carica papaya,* 8-VI-1999, by H. González, J. Villaneuva, D. R. Miller (1 ad. ♀); near Tecoman, Boca de Pazcuales, on *Carica pa-*

Table 3. Morphological comparisons of selected first instars, second-instar females, third-instar females, and adult females of *Paracoccus marginatus* and other economically important mealybugs. Bold indicates characters that differ from *Paracoccus marginatus.*

	First Instar		Second-Instar Female			Third-Instar Female			Adult Female		
	Anal Bar	# Cerarii	Anal Bar	# Cerarii	Oral Rims	Anal Bar	# Cerarii	Oral Rims	Anal Bar	# Cerarii	Oral Rims
Paracoccus marginatus	yes	7–10	yes	4–11	no	yes	17	no	yes	17	yes
Dysmicoccus brevipes	**no**	**17**	**no**	**17**	no	**no**	17	no	**no**	17	**no**
Ferrisia virgata	**no**	**1**	**no**	**1**	**yes**	**no**	**1**	**yes**	**no**	**1**	yes
Maconellicoccus hirsutus	yes	**1–2**	yes	**3–4**	**yes**	yes	3–4	**yes**	yes	**4–7**	yes
Nipaecoccus nipae	yes	**17**	?	?	?	yes	**10+**	no	**no**	**10+**	**no**
Phenacoccus gossypii/madeirensis	yes	**15–18**	yes	**15–18**	no	yes	**18**	no	yes	**18**	**no**
Phenacoccus solenopis	yes	**15–18**	yes	**15–18**	no	yes	**18**	no	yes	**18**	no
Planococcus citri/minor	yes	**18**	yes	**18**	no	yes	**18**	no	yes	**18**	**rare**
Pseudococcus jackbeardsleyi	**no**	**17**	**no**	**17**	no	**no**	17	**yes**	**no**	17	yes
Pseudococcus longispinus	yes	**17**	yes	**17**	**yes**	yes	17	**yes**	yes	17	yes
Pseudococcus viburni	**no**	**17**	**no**	**17**	no	**no**	17	**yes**	**no**	17	yes

paya, 8-VI-1999, by H. González, J. Villaneuva, D. R. Miller (2 ad. ♀, 1 third-instar ♂); Laguna de Chanchopan, on *Carica papaya,* 10-II-2000, by H. González, J. Villaneuva, M. E. Schauff, D. R. Miller (8 first instar); Puerta de Caberar, on *Carica papaya,* 7-II-2000, by H. González, J. Villaneuva, M. E. Schauff, D. R. Miller (1 ad. ♀, 4 first instar); Plan de Zapotes, on *Carica papaya,* 10-II-2000, H. González, J. Villaneuva, M. E. Schauff, D. R. Miller (4 ad. ♀, 2 ad. ♂, 3 third-instar ♀, 2 second-instar ♂); Colima City, 7-II-2000, on *Carica papaya,* H. González, J. Villaneuva, M. E. Schauff, D. R. Miller (2 ad. ♀, 1 third-instar ♀, 1 second-instar ♀, 1 second-instar ♂). Guerrero—Acapulco Airport, on *Sida* sp., 15-IV-1984, by J. Gillet and H. Miranda (1 ad. ♀); El Carrizal, on *Mimosa pigra,* 7-VII-1986, by J. Gillett (1 ad. ♀). Jalisco—San Marcos, on *Carica papaya,* 6-II-2000, by H. González, J. Villaneuva, M. E. Schauff, D. R. Miller (1 ad. ♀). Michoacan—near Nueva Italia, on *Carica papaya,* 5-II-2000, by H. González, J. Villaneuva, M. E. Schauff, D. R. Miller (2 ad. ♂, 5 third-instar ♀, 4 second-instar ♀); Santa Casilda, on *Carica papaya,* 9-VI-1999, by H. González, J. Villaneuva, D. R. Miller (20 ad. ♀, 3 ad. ♂, 2 third-instar ♀, 1 third-instar ♂, 3 second-instar ♀, 15 first instar). Tobasco—Ejido Lopez Portillo, on *Hibiscus* sp., 4-VI-1999, by H. González, D. R. Miller (1 ad. ♀); Rancherias Barrancar y Amate, on *Carica papaya* and *Manihot esculenta,* 4-VI-1999, H. González, D. R. Miller (2 ad. ♀); Villahermosa, on *Mimosa pigra,* 18-III-1985, by J. Gillet (11 ad. ♀); Villahermosa, on *Hibiscus* sp., 4-VI-1999, by H. González, D. R. Miller (1 ad. ♀). Vera Cruz—Campo Cotaxtla, on *Carica papaya,* 2-VI-1999, by H. González, J. Villaneuva, D. R. Miller (4 ad. ♀); Curva del Pato Santa Fe, on *Hibiscus* sp. and *Manihot esculenta,* 2-VI-1999, by H. González, J. Villaneuva, D. R. Miller (8 ad. ♀); El Mangal, on *Carica papaya,* 2-VI-1999, by H. González, J. Villaneuva, D. R. Miller (7 ad. ♀); Huexotla, on *Carica papaya,* 2-VI-

1999, by H. González, J. Villaneuva, D. R. Miller (1 ad. ♂), Manilo Fabio Altamirano, on *Hibiscus* sp., 2-VI-1999, by H. González, J. Villaneuva, D. R. Miller (5 ad. ♀, 3 third-instar ♀, 1 second-instar ♀); Oaxaquilla, on *Carica papaya,* 2-VI-1999, by H. González, J. Villaneuva, D. R. Miller (33 ad. ♀, 9 third-instar ♀, 9 second-instar ♀, 14 second-instar ♂, 2 first instar); Santa Fe, on *Manihot esculenta,* 2-VI-1999, by H. González, J. Villaneuva, D. R. Miller (5 ad. ♀, 1 third-instar ♀); Tepetates, Colegio de Postgraduados, on Leguminosae, 5-VI-1999, by H. González, J. Villaneuva, D. R. Miller (41 ad. ♀, 4 third-instar ♀, 4 second-instar ♀); Vera Cruz (intercepted at El Paso, Texas), on *Carica papaya,* 25-IV-1983, by R. Venezia (3 ad. ♂). Unknown State—locality unknown (intercepted at Nogales, Arizona), host unknown, 21-VII-1991, by G. Kluzik (2 ad. ♀); locality unknown (intercepted at Nogales, Arizona), host unknown, 5-IX-1991, by T. Giles (1 ad. ♀); locality unknown (intercepted at El Paso, Texas), on *Zea mays,* 20-XI-1992, by H. Grieb (1 ad. ♀). PUERTO RICO: Locality unknown, on *Hibiscus* sp., 24-II-1994, by J. Morales (2 ad. ♀); Locality unknown, on *Carica papaya,* 16-X-1995, by unknown collector (3 ad. ♀). ST. KITTS: Basseterre, CARDI Experimental Farm, on *Carica papaya,* 27 and 26-VII-2000, by G. L. Miller (12 ad. ♀, 1 ad. ♂, 4 third-instar ♀, 11 second-instar ♀, 13 second-instar ♂, 15 first instar). U.S. VIRGIN ISLANDS: St. Croix, on *Plumeria* sp., 16-VIII-1994, by K. Jenkins (1 ad. ♀); St. Thomas—Botany Bay, on *Carica papaya,* 2-VI-1998, by M. E. Schauff and D. R. Miller; near Dorothea Bay, on shrub, 3-VI-1998, by M. E. Schauff and D. R. Miller; John Brew's Bay, on *Acacia* sp., 3-VI-1998, by D. R. Miller; Magens Bay, on *Coccoloba* sp., 4-VI-1998, by M. E. Schauff and D. R. Miller; near Redhook Ferry, Smith Bay, on unknown host, 4-VI-1998, by M. E. Schauff and D. R. Miller; Smith Bay, on leguminose tree, 4-VI-1998, by M. E. Schauff and D. R. Miller; Locality unknown, on *Solanum tuberosum* (in culture), 9-V-2000, by C. Francis (36 ad. ♀, 51 ad. ♂, 8 fourth-instar ♂, 5 third-instar ♀, 14 third-instar ♂, 7 second-instar ♀, 23 second-instar ♂, 41 first instar); Locality unknown, on *Solanum tuberosum* (in culture), 8-VIII-2000, by R. Warkentin (2 ad. ♂, 2 third-instar ♀, 1 third-instar ♂, 24 second-instar ♀, 30 second-instar ♂).

Discussion

A synopsis of selected diagnostic information for slide-mounted adult females of *Paracoccus* occurring in Central and South America is presented in Table 2. Two characters that are important for distinguishing *P. marginatus* from all other species of New World *Paracoccus* are: (1.) presence of oral-rim tubular ducts only on the margin (unique with *P. marginatus*) and (2.) absence of pores on the hind tibiae (only *P. townsendi* and *P. villanuevai* also lack pores on the hind tibiae). In addition, adult females of *P. marginatus* differ from other members of the genus found in Central and South America by having the following combination of characters: a circulus; up to 8 pairs of abdominal cerarii; oral rim tubular ducts present on the dorsal surface; multilocular disk pores absent from ventral lateral margins of thorax; oral rim tubular ducts absent from dorsum of anal lobe; and dorsal oral rim tubular ducts present near margins.

Tables 3–6 also include some diagnostic characters for comparing first instars, second-instar females, third-instar females, and adult females and males to various other mealybugs found on similar hosts to *P. marginatus.* First instars of *P. marginatus* differ from the first instars of many other mealybugs by having an anal bar, a circulus, and 7–10 pairs of indefinite cerarii that are represented by 1 conical seta 1 smaller seta and 1 or 2 associated trilocular pores (see also Table 3). Second-instar *P. marginatus* females differ from the second-instar females of many other mealybugs by having an anal bar, a circulus, and 4–11 pairs of indefinite cerarii (see also Table 3). Sec-

Table 4. Morphological comparisons of second-instar males of *Paracoccus marginatus* and other economically important mealybugs. Bold indicates characters that differ from *Paracoccus marginatus*.

	Second-Instar Male				
	Multilocular Pores	Anal-lobe Bar	# Cerarii	Discoidal Pore Near Eye	Oral Rim Tubular Ducts
Paracoccus marginatus	present	present	10+ pair	absent	absent
Dysmicoccus brevipes	**absent**	**absent**	17 pair	**present**	absent
Ferrisia virgata	**absent**	**absent**	**1 pair**	absent	absent
Maconellicoccus hirsutus	**absent**	present	**1 or 2 pair**	absent	usually absent
Nipaecoccus nipae	present	present?	10+ pair	**present**	**present**
Phenacoccus gossypii/madeirensis	**absent**	present	15–18	absent	absent
Phenacoccus solenopsis	**absent**	present	15–18	absent	absent
Planococcus citri/minor	present	present	10+ pair	absent	absent
Pseudococcus jackbeardsleyi	**absent**	**absent**	17 pair	**present**	absent
Pseudococcus longispinus	**absent**	present	17 pair	absent	absent
Pseudococcus viburni	**absent**	**absent**	17 pair	**present**	absent

ond-instar males of *P. marginatus* differ from the second-instar males of many other mealybugs by having multilocular disk pores on dorsum and venter of thorax, an anal bar, a circulus, 10 or more pairs of indefinite cerarii, and numerous dorsal oral-collar tubular ducts (see also Table 4). *Paracoccus marginatus* third-instar females differ from the third-instar females of many other mealybugs by lacking oral-collar and oral-rim tubular ducts and multilocular pores; and by having an anal bar, circulus, and 17 pairs of indefinite cerarii (see also Table 3).

In comparison with the species listed in Table 5, adult males of *P. marginatus* are different from the other species listed by the following two characters: (1.) presence of stout fleshy setae on the antennae and (2.) absence of fleshy setae on the legs. *Paracoccus marginatus* adult males are most similar to *Planococcus citri* (Risso) but, in addition to the aforementioned characters, *P. marginatus* differs by having margins of abdominal segments I with 5(3–7) multilocular pores in each lateral cluster, usually without multilocular pores on head, and a broad aedeagus. *Planococcus citri* has long fleshy setae on the antennae, many fleshy setae on the legs, margins of abdominal segments I with 14(11–18) multilocular pores in each lateral cluster, usually with 2 multilocular pores on head, narrow aedeagus.

Although examination of microscope slide-mounted material is imperative for proper species determination, field characters are sometimes useful for preliminary identification. Table 6 includes a comparison between *P. marginatus* and common mealybugs based on the number of lateral filaments, caudal filament length as compared to body length, body color, dorsal body stripes, and position of the ovisac. A category for other unique characters is also included. *Paracoccus marginatus* can be distinguished readily from the other included species by caudal filament length, body color, and position of the ovisac.

Invasive scale insect pests are responsible for millions of dollars in crop loss in the United States. *Paracoccus marginatus* represents yet another scale insect that has drawn attention as an invasive species. It, other scale pests, and potential scale pests have recently been identified because of their threat to U.S. agriculture (Miller and Miller, in press). A critical element in any program that involves control or management of an insect pest should always first begin with the correct identification. This paper contributes toward this end. We found that all stages of *P. marginatus* can be separated intraspecifically. In addition,

Table 5. Morphological comparisons of adult males of *Paracoccus marginatus* and other economically important mealybugs. Bold indicates characters that differ from *Paracoccus marginatus*.

	Adult Male (Fifth Instar)						
	Fleshy Setae on Legs	Fleshy Setae on Abdomen	Fleshy Setae on Antennae	Lateral Clusters of Pores on Abdomen	Tail-forming Pore Clusters	Setae on 8th Abdominal Tergite	Lateral Preanal Stigmatic
Paracoccus marginatus	no	no	short	small, all segments	1 pair	rarely	small
Dysmicoccus brevipes	**yes**	**yes**	**long**	small, all segments	1 pair	**yes**	absent
Ferrisia virgata	**yes**	**yes**	**long**	small, all segments	1 pair	**yes**	**absent**
Maconellicoccus hirsutus	**yes**	no	**long**	**small, anterior segments**	1 pair	**yes**	**absent**
Nipaecoccus nipae	**yes**	no	**long**	**large, all segments**	1 pair	**yes**	small
Phenacoccus gossypii/madeirensis	**yes**	no	**long**	small, all segments	2 pair	**yes**	**absent**
Phenacoccus solenopis	**yes**	no	**long**	small, 0–3 on all segments	2 pair	**yes**	**absent**
Planococcus citri/minor	**yes**	no	**long**	**large, all segments**	1 pair	**yes**	small
Pseudococcus jackbeardsleyi	**yes**	**yes**	**long**	**large, all segments**	1 pair	**yes**	**absent**
Pseudococcus longispinus	**yes**	**yes**	**long**	small, all segments	1 pair	**yes**	**large**
Pseudococcus viburni	**yes**	**yes**	**long**	**large, all segments**	1 pair	**yes**	**absent**

Table 6. Field character comparisons of adult females of *Paracoccus marginatus* and other economically important mealybugs. Bold indicates characters that differ from *Paracoccus marginatus*.

	Field Characters of Adult Females					
	# Lateral Filaments	Caudal Filament Length to Body Length	Body Color	Dorsal Body Stripes	Position of Ovisac	Other Unique Characters
Paracoccus marginatus	many	about ¼	**greenish yellow**	no	beneath and behind body	
Dysmicoccus brevipes	many	¼ to ½	**pink**	no	**no**	
Ferrisia virgata	**1 pair**	¼ to ½	grayish	**2**	**no**	**crystalline rods on dorsum**
Maconellicoccus hirsutus	**absent, rarely 1 or 2**	short	**reddish brown**	no	beneath body	
Nipaecoccus nipae	many	about ¼	**red**	no	**no**	**filaments on dorsum**
Phenacoccus gossypii/madeirensis	many	less than ¼	gray	**2**	**covers body**	
Phenacoccus solenopis	many	less than ¼	green	**2**	**no**	large body
Planococcus citri/minor	many	less than ¼	**pink**	**1**	beneath body	
Pseudococcus jackbeardsleyi	many	**about ½**	**pink?**	no	**covers part of body**	**filaments thin**
Pseudococcus longispinus	many	**as long as body**	gray	**1**	**no**	**hind 2 pair of filaments long**
Pseudococcus viburni	many	**about ½**	**pink**	no	**covers part of body?**	**filaments thin**

we have listed various synoptic characters which are diagnostic when compared with many of the common pests that occur on similar hosts of *P. marginatus*.

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Literature Cited

Afifi, S. 1968. Morphology and taxonomy of the adult males of the families Pseudococcidae and Eriococcidae (Homoptera: Coccoidea). British Museum (Natural History), 2nd Report on Economic Zoology 13: 3–210.

Anonymous. 2001. Integrated Taxonomic Information System [web page] http://www.itis.usda.gov/plantproj/itis/itis_query.html [accessed 3 May 2001].

Ben-Dov, Y. 1994. A systematic catalogue of the mealybugs of the world. Intercept Ltd., Andover, UK, 686 pp.

Gimpel, W. F. and D. R. Miller. 1996. Systematic analysis of the mealybugs in the *Pseudococcus maritimus* complex (Homoptera: Pseudococcidae). Contributions on Entomology, International 2: 1–163.

Hattingh, V. 1993. Mealybugs and cottony cushion scale on citrus in Southern Africa. Citrus Journal 3: 20–22.

Matile-Ferrero, D. and J. Étienne. 1996. Présence de la Cochenille de l'Hibiscus, *Maconellicoccus hirsutus* à Saint-Martin (*Hemiptera, Pseudococcidae*). Revue Francaise d'Entomologie (Nouvelle Serie) 18: 38.

———. 1998. *Paracoccus marginatus* Williams and Granara de Willink, nouvelle introduction en Guadelopupe et à Saint-Barthélemy (Hemiptera, Pseudococcidae). Revue Française d'Entomologie (Nouvelle Serie) 20: 142.

Matile-Ferrero, D., J. Étienne, and G. Tiego. 2000. Introduction de deux ravageurs d'importance pour la Guyane française: *Maconellicoccus hirsutus* et *Paracoccus marginatus* (Hem., Coccoidea, Pseudococcidae). Bulletin de la Société entomologique de France 105: 479–485.

Miller, D. R. and G. L. Miller. In Press. Invasive species of mealybugs and their threat to U.S. agriculture (Hemiptera: Pseudococcidae). Proceedings of the Entomological Society of Washington.

Miller, D. R., D. J. Williams, and A. B. Hamon. 1999. Notes on a new mealybug pest in Florida and the Caribbean: The papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink. Insecta Mundi 13: 179–181.

Watson, G. W. and L. R. Chandler. 1999. Identification of mealybugs important in the Caribbean region. Commonwealth Science Council and CAB International, London. 40 pp.

Williams, D. J. and M. C. Granara de Willink. 1992. Mealybugs of Central and South America. CAB International, London, England. 635 pp.